Nailing Down Ice in a Cloud Model

Research Highlight

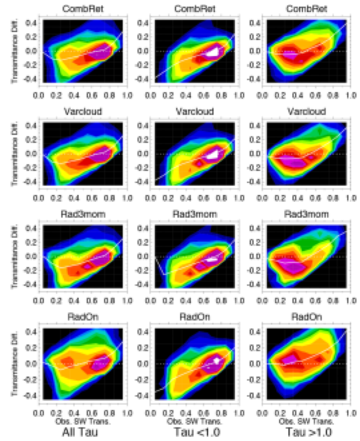
A research team led by scientists at Pacific Northwest National Laboratory identified specific strengths and weaknesses of four different ice cloud retrieval algorithms. Their comparisons tested the ability of the algorithms to obtain cloud properties from radar and lidar observational measurements. The team noted the sometimes large variances in heating/cooling measurements compared to the observed data. Identifying specific weaknesses will help scientists improve our understanding of cloud properties in the atmosphere, which can be used for climate model development and evaluation.

"Measuring the effective size and mass of ice crystals impacts our understanding of clouds' reflective nature," said Dr. Jennifer Comstock, atmospheric scientist and lead author of the study. "Describing how these clouds contribute to the heating and cooling of the atmosphere gives climate modelers important information to predict future climate change."

The team, led by PNNL's Dr. Jennifer Comstock, used four different algorithms to uncover ice crystal size and ice mass cloud properties using an identical input observational dataset. They computed the radiative fluxes at the surface and top-of-atmosphere for these cloud properties using a radiative transfer model. Then, the team compared the computed fluxes with 3 years of ground-based lidar and radar observations from the Atmospheric Radiation Measurement (ARM) Climate Research Facility Tropical Western Pacific site in Darwin, Australia to help determine the algorithm's proficiency (uncertainty).

The bias and variance of the difference between computed and observed fluxes showed major differences between individual algorithms. The study identified individual algorithm weaknesses and assumptions that need improvement. They found that assumptions concerning ice crystal shape and the representation of ice crystal size are the primary drivers of the uncertainty in the models.

Building a house involves detailed instruction sets for separate systems such as plumbing, heating, and carpentry, to name a few. Climate models need similar instruction sets called algorithms to represent different climate properties and systems. For the best results scientists need to find the best algorithms. To compare how well a model represents clouds and their effects on the warming and cooling of the climate, scientists rely on direct observations to evaluate the skill of those representations in climate models. These comparisons also help them assess the models' ability to simulate clouds. The research described in this paper evaluates several ice cloud property algorithms to zero in on how well each can measure particular cloud properties, and whether that level of skill impacts our overall understanding of clouds' effects on the energy balance of the planet.



Uncertainty in atmospheric transmittance as a function of optical depth for 4 different retrieval algorithms. Joint distributions of transmittance difference reveal the mean bias and variance in algorithm performance.

Reference(s)

Comstock JM, A Protat, SA McFarlane, J Delanoë, and M Deng. 2013. "Assessment of Uncertainty in Cloud Radiative Effects and Heating Rates Through Retrieval Algorithm Differences: Analysis using 3 Years of ARM Data at Darwin, Australia." Journal of Geophysical Research – Atmospheres, 118(10), doi:10.1002/jgrd.50404.

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Cloud Life Cycle